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The purpose of this thesis was to examine and better explain the spatial distribution of computer and electronic product manufacturing employment by MSA. It will be argued that the geography of computer and electronic product manufacturing is strongly linked to specific socio-economic variables and particularly Richard Florida's Creative Index score by MSA.

The analysis was based on a series of non-parametric Spearman's Rank Correlation Coefficients, which were used to determine if statistically significant relationships existed between the dependent and independent variables. In general, the geographical dispersion of computer and electronic product manufacturing employment has statistically significant relationships with educational attainment, median value of homes, and the percent of a population born outside the United States. However Richard Florida's Creative Index generated the highest correlation coefficient score, when compared to the percentage of the labor force employed in computer and electronic product manufacturing by MSA.

THE GEOGRAPHY OF TECHNOPOLES: COMPUTER AND ELECTRONIC

PRODUCT MANUFACTURING BY MSA, 2005

by

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Approved by

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Committee Chair

In loving of memory

of Eddie Corley Miller

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

The geographic clustering of industries and the competitive advantage that they provide is well documented (Porter, 2000). There has been a substantial amount of research on the clustering of a variety of industrial sectors; however, there is surprisingly little research that focuses exclusively on computer and electronic manufacturing. The success of this particular area of manufacturing is contingent upon significant technological inputs and skills. It is the intent of this thesis to investigate the spatial distribution of the computer and electronic product manufacturing sector by metropolitan statistical area in an attempt to better understand high tech clusters and the key critical variables that allow them to flourish.

The economy of the United States is rapidly evolving and changing in response to the influences of globalization and the market place. Information technology is providing a means to manipulate, send, and house digital information at an unprecedented rate and at a low cost to the consumer. This emerging ‘New E-conomy’ represents a significant leap forward in technology comparable to that witnessed during the Industrial Revolution (Cohen et al, 2000). The New Economy is defined as “a global knowledge and idea based economy where the keys to wealth and job creation are the extent to which ideas, innovation, and technology are embedded in all sectors of the economy – services, manufacturing, and agriculture” (Atkinson and Gottlieb 2001).

Powerful economic clusters are becoming instrumental components of this New Economy. Clusters provide a competitive advantage by allowing firms and regions to rapidly react to changing economic conditions (Devol and Wallace 2004). Clusters promote economic relationships between firms by utilizing shared infrastructure and social institutions (Krugman, 1993). Clusters also foster the creation of spin-offs which manifest themselves through the multiplier effect throughout entire metropolitan regions.

Clusters can be described as geographic concentrations of interconnected firms that share specialized suppliers, service providers, and similar associated institutions in a particular region (Porter, 2000). Clusters provide an arena for extremely high levels of productivity and innovation. The importance of location is often argued to be diminishing as a result of technological advancements in communication and transportation. This notion, however, is often exaggerated, as location continues to play a vital role in competition. Porter (1998) describes clusters as critical masses of linked industries and institutions ranging from suppliers to universities to government agencies, enjoying competitive success in a given field.

The development of clusters has evolved over time (Scott, 1984). Many of the first clusters utilized the location of certain natural resources such as coal or steel, while other locations possessed distinct transportation advantages. The presence of certain institutions such as universities and other existing companies has been proven to influence the location of certain industries (Scott, 1993). The evolution of clusters can often take considerable time; however, the process can often be expedited by elected officials and business leaders who understand the potential rewards for their region (Ketels, 2003).

A simple way to better understand the geography of these ‘new economy’ technopoles is to measure the data for specific high tech sectors using NAICS codes. The North American Industry Classification System (NAICS) is a result of a combined effort between the United States, Canada, and Mexico to produce a uniform classification structure for economic data. NAICS replaced the Standard Industrial Classification (SIC), which was used for over 60 years and was outdated and lacking in detail. NAICS arranges industrial establishments according to their production process. This system provides a method of examining economic statistics that reflect the nation’s change to a ‘new economy’. Under the new NAICS codes, manufacturing is categorized to identify newer high tech industries, including a subsector dedicated to computers and electronics. The first NAICS manual was published in 1998 and is updated annually. NAICS serves as the method of industry classification for data compiled by the Bureau of Labor Statistics (NAICS, 2002). The 2002 NAICS manual defines computer and electronic product manufacturing (NAICS 334) as “establishments that manufacture computers, computer peripherals, communications equipment, and similar electronic products, and establishments that manufacture components for such products” (NAICS, 2002).

It is hypothesized in this thesis that the geography of the computer and electronic product manufacturing industry by metropolitan statistical area is fundamentally shaped by several key socio-economic variables including educational attainment level, per capita income, median housing price, median age, percent foreign born, and percentage population growth rate from 1990 to 2005. These traditional variables coupled with Richard Florida's creative index score, will be used to explain the specific geography of the computer and electronic product manufacturing industry. It is likely that the skills required to be employed in the computer and electronic product manufacturing sector will manifest themselves in MSAs that value education and promote a healthy knowledge infrastructure. It is the intent of this thesis to illustrate the competitive advantage that exists among select MSAs in the computer and electronic product manufacturing industry.

Metropolitan Statistical Areas provide the most appropriate geographical unit of analysis because they effectively represent today's regional labor markets. A Metropolitan Statistical Area is a geographic unit defined by the Office of Management and Budget that possesses a minimum of one urbanized area of 50,000 or more inhabitants and adjacent communities that have a high degree of economic and social integration with the core area through commuting patterns. The largest 100 MSAs that reported total employees in the computer and electronic product manufacturing industry will be analyzed in this thesis, those 100 metropolitan areas account for over 78% of the total U.S. employment in this sector.

CHAPTER II

LITERATURE REVIEW

The thesis begins with a literature review of previous studies on industrial clusters. The first half of this review is mainly an overview of clusters and economic geography, whereas the second half strives to examine in more detail the emerging "E-conomy" and the computer and electronic product manufacturing industry in detail.

1. Overview of Industrial Clusters

Industry clusters "may be defined very generally as a group of business enterprises and non-business organizations for whom membership within the group is an important element of each member firm's individual competitiveness. Binding the cluster together are buyer-supplier relationships, or common technologies, common buyers or distribution channels, or common labor pools (Enright 1996, p. 191)." Competition is critical among clusters and economic achievement and self preservation serve to connect firms (Enright, 1996).

Regional industry clusters are clusters that share a common geography or location; which is most commonly comprised of a metropolitan area, labor pool, or some other economic entity (Bergman and Feser, 1999). Regional clusters are comparable to previous concepts that focused on the importance of geography and cooperation among firms to gain an economic advantage. Business networks, industrial complexes, and innovative milieu provide a foundation for examining regional clusters.

Business networks are usually somewhat limited and may require a contractual agreement. Members of a network choose to cooperate with each other for numerous reasons; however economic prosperity is paramount. Relationships among firms in business networks often lead to familiarity and create stronger bonds than are found in most cluster situations (Rosenfeld, 1997). Industrial Complexes are comprised of a group of industries that share a stream of goods and services, but are further bound by location (Czamanski and de Ablas, 1979). An innovative milieu can neither be defined as a business or a region, but rather is an intricate relationship between economic and technological interdependencies (Maillat, 1991).

Michael Porter (2003) strives to explain the growing importance of regional economies as they relate to the broader national economy. Four variables; wages, wage growth, employment growth, and patenting are empirically analyzed to investigate the regional performance in the U.S. economy. Porter (2003) found that regional economic performance was strongly bound to the health of existing clusters and the amount of innovation present.

Evidence suggests that regional analysis needs to become much more central to research regarding economic development policy. The regional level provides a much more accurate measure of economic performance than an examination of national polices. It is argued that nations with greater degrees of economic decentralization, such as Germany and the U.S. enjoy further success (Porter, 2003). Porter (2003) gives particular significance to the presence of traded clusters, which provide higher wages and serve as a general catalyst for local employment. The importance of constructing innovative capacity and diversity are discussed in tremendous detail.

Bergman and Feser (1999) examine the concept of value-chain clusters by investigating firms trading habits between affiliates. These trading habits can be direct or indirect through outside partners (Bergman and Feser, 1999). Further study of value-chain dynamics illustrates that linkages present between firms may not always be in the form of product or supply trade. In many cases the flow of knowledge and labor are found to be the commodity traded (Bergman and Feser, 1999).

Feser et al (2005) provide an empirical analysis of five U.S. value chains: IT, apparel, motor vehicles, transportation and shipping, and pharmaceuticals. Data was taken from the time period 1989-1997 and used to locate discrete industrial complexes. The paper utilizes innovative approaches to spatial data analysis; the G statistic measuring industrial geography, serves to better isolate locations of similar value chain activity (Feser et al, 2005).

The majority of previous empirical analysis concerning industrial clusters focuses on examining already existing and identified business linkages. *A Descriptive Analysis of Discrete U.S. Industrial Complexes* (Feser et al, 2005) emphasizes the need to locate clusters that are not already known by employing the industrial complex model (Feser et al, 2005). Feser et al (2005) acknowledges that numerous methodological limitations exist; however the results are statistically significant. A specific example can be seen in the discovery of an IT cluster in Indian River County Florida. The point of particular focus is this cluster was found to be completely independent of influential counties to the north, specifically Brevard County, home of the Kennedy Space Center (Feser et al, 2005).

Competitive Advantage is a term that has received much attention since its inception in Michael Porter's (1990) *Competitive Advantage of Nations.* This book focuses on economic advantages that persist in nations and investigates how geography plays an instrumental role in those advantages. Porter (1990) examines the competitive resources of multiple nations and provides further evidence that linkages and spillovers are the catalyst for much of the industry growth and innovation that can be found. Porter (1990) introduced the diamond concept, a foundation that has changed the manner in which economic geography is presented, which illustrates four critical aspects of regional competitiveness.

Firm Strategy, structure, and rivalry encompass a nation's ideas towards competition and the market strategies it may employ. This component also is made up of social and historical factors that influence how their economy operates. Factor conditions are comprised of resources that determine competitiveness, such as natural resources, technology and the skill and size of the labor pool. Demand conditions measure the local need for goods and services produced both locally and imported. Finally, the existence of related and supporting industries is critical in providing suppliers and competitive industries. These factors can promote rivalry and serve to create a competitive advantage (Porter, 1990).

Competitive industries are closely coupled with the success of their suppliers, who are linked to them through the value chain. Industries must rely on the health of their service providers who are responsible for such things as management, financing; and in the high technology sector, sources of R&D. Competition among the primary industry as well as among its suppliers is crucial to the economic well being of the entire supply chain (Bergman and Feser, 1999).

It is quite apparent that industry clusters in reality, often bear little resemblance to the somewhat ideal type portrayed by Porter. The theories or key points discussed by Porter are seldom accompanied by specifics. For this reason it is important to examine further studies to identify the foundation and explanations of industry clusters and provide information concerning the advantages of regional industrial clusters. Many researchers including Enright (1996) believe spatial clustering can largely be explained by ideas of business externalities, knowledge spillovers, and viable labor pools. Others believe that the relationship between non-business institution such as universities, trade schools, unions, and other entities are paramount. Rivalry and competition, specific marketing, and civic capacity are among the most cited foundations for successful industrial clusters (Bergman and Feser, 1999).

Gordon and McCann (1999) strongly support the notion that industrial activities tend to be concentrated in specific locations. They emphasize the argument that there is a considerable amount of uncertainty and vagueness in the manner in which industrial clusters are utilized in research. The principle motivation for their investigation is that discourse surrounding industrial clusters stems from various perspectives (Gordon and McCann, 1999). There are three methods of spatial industrial clustering offered by

Gordon and McCann, (1999) that must be understood in context to properly analyze industrial clusters. These models are tested empirically in the City of London.

The model of pure agglomeration provides two advantages for firms to consider. Agglomeration tends to provide economies of scale regarding the dispersal of capital and promotes the efficient transfer of technology (Gordon and McCann, 1999). The industrial complex model concentrates on the importance of location and linkages among firms. How the location of firm affects transactional and production costs is examined in detail. This model has evolved from simple location theory to an investigation of just in time complexes which are thriving today (Gordon and McCann, 1999). The final model, developed in sociological literature, is the social-network model. This theory holds social capital and personal interaction as the predominant catalyst for clustering (Gordon and McCann, 1999).

Lundmark and Power (2004) exhibit findings consistent with their hypothesis that emerging clusters will show high rates of labor mobility. Evidence of this theory persists throughout all employment types. High rates of labor mobility are examined and found to facilitate knowledge dispersion and cluster creation (Lundmark and Power, 2004). The investigation of labor flow strength also shows that interactions within the clusters are considerably higher than those within the outside labor market.

Lundmark and Power (2004) analyze a large data set consisting of over 1.1 million records, covering taxation and civil registration records in the Stockholm metropolitan area. A data set of this magnitude adds to the validity of this study, providing economic details of individuals who have worked or earned money in a particular cluster. The process of identifying and examining the impact of clusters remains undefined; however, Lundmark and Power (2004) provide a valuable method of research. They contend that studying the intensity of labor mobility and linkage among clusters is a valuable method of defining and acknowledging industrial clusters (Lundmark and Power, 2004).

Jacobs and De Man (1996) examine clusters from a Dutch perspective, providing general characteristics that define the cluster concept. Clusters are comprised of a network of suppliers that surround a particular core enterprise, making each cluster unique. Jacobs and De Man (1996) provide insight into three broad explanations of Cluster activity. Regional clusters, vertical production chains, and the focus on large aggregations or collection of sectors provide the foundation for the majority of cluster research (Jacobs and De Man (1996).

Jacobs and De Man (1996) find that a tremendous amount of advancement or improvement can result from existing clusters. Innovation can come in many forms; organizational tactics can encourage new partnerships within clusters and networks. Many defensive policies, aimed at protecting resources, serve to stifle innovation. Findings suggest that there is not a definitive cluster approach that can be used by governments and firms, rather each case must be assessed on an individual bases (Jacobs and De Man).

Scott and Storper (2003) address their concern that economists have neglected economic geography. It is recognized; however, that economists have afforded more effort in the study of agglomeration economies and regional linkages. This paper stresses the level of maturity that regional economies have attained. Regions have progressed to become crucial elements of economic organization, on par with firms, sectors and nations (Scott and Storper, 2003).

Scott and Storper (2003) provide particular insight into the study of poorer countries, implying that previous studies have placed too high of a priority on hyperurbanization and its negative consequences. The main concern for developing countries should encompass how to create and sustain the types of economic agglomerations that will raise their regional economies up to the global level. The purpose of their paper was to move beyond the concepts of development theory and begin to tackle the hard economic questions facing developing regions around the world (Scott and Storper, 2003).

An overview of the current literature suggests that there are five major concepts that lay the groundwork for theoretical regional cluster studies: external economies, the innovation environment, cooperative competition, interfirm rivalry, and path dependence (Bergman and Feser, 1999).

A. External Economies

External economies focus on why industries cluster into a specific geographic space and how such clustering affects the economic growth of regions. There are two major ideas presented by Weber and Marshal that concentrate on this topic. Weber (1929) illustrates Industrial *Location Theory* by referring to the benefits of clustering as agglomeration of economies. Agglomerations of economies are further explained as the monetary savings afforded a firm due to clustering. The reasons for agglomeration were not a primary focus in Location Theory (Weber, 1929). Marshal (1961) defines external scale economies as cost savings accruing to the firm because of size or growth of output in industry generally. Marshal (1961) illustrates the dynamics of external economies by providing evidence of large labor pools, significant opportunity for specialization, and knowledge spillovers present where firms found themselves concentrated in specific clusters or districts. The ideas of Marshal (1929) can be seen in the work of Porter (1990) many years later.

B. Innovative Environment

An innovative environment is a critical asset for the success of a firm. Alliances and interactions between firms, universities and other institutions are the catalyst for innovative success (Roelandt and den Hertog, 1999). Innovation is a social process that seems to be most successful when a strong relationship exists between those that invent new products and the commercial machine that markets them (Roelandt and den Hertog, 1999). Industry clusters are extremely beneficial in transmitting tacit knowledge that is not easily transmitted among industries, instead requiring a personal transfer. This is most evident in high technology firms; however it is certainly not exclusive to that sector. External characteristics of a regional environment may also aid in the innovative capacity of a firm; Saxenian (1994) illustrates that land use and design may also play a role in the innovative process. Maillat (1991) argues that the innovative milieu may also foster the process of innovation. Although the milieu is not a tangible entity, it is a complex economic system comprised of linkages, transactions, and partnerships that operate in concert to promote a collective positive atmosphere for innovation (Malecki, 1997).

C. Cooperative Competition

Cooperative Competition is a significant factor that is investigated when examining industrial clustering. Simply defined, cooperative competition is the manner in which competitive firms work together, while at the same time battling each other for their share of the market (Bergman and Feser, 1999). Doeringer and Terkla (1997) supply two examples where cooperation among firms located in close proximity is mutually beneficial. The first is when just-in-time (JIT) inventory and delivery tactics are utilized. Doeringer and Terkla (1997) investigate location patterns of Japanese manufacturers and suppliers which prove critical in allowing the JIT process to operate efficiently. A second example exemplifies the necessity of speed and regularity of interactions between the firms in a regional cluster. The speed and efficiency among suppliers is important when firms can purchase supplies from multiple vendors. One weakness of the previous two examples is that they deal only with market producers and suppliers and do not touch on competing producers. Enright (1996) underlies the need to distinguish between horizontal and vertical means of cooperation because the costs and benefits can vary immensely. Competing market producers may collectively allocate resources for advertising and marketing, research, and infrastructure requirements.

D. Interfirm Rivalry

Although rivalry may seem to contradict the previous concept of cooperative competition, Porter (1998) believes that competition for the same market drives industries to continue to innovate and strive for more efficient methods of production. Rivalry is offered as a viable defense for industry and firm complacency. Rivalry is further amplified among firms located in a particular location or geography, as they not only compete for consumers, but for resources, labor, publicity, and political backing as well (Porter, 1998). It is further argued by Scott, (1984) that small firm rich locations with a particularly high level of innovation and diversity hold an advantage over large firm single industry locations.

E. Path Dependence

Path dependence or the notion that institutions are self reinforcing is particularly relevant and used to explain the technology adaptation process and industry evolution. The focus is on knowledge related externalities as a source of increasing revenue, most often found in high technology industries (Krugman, 1993). Krugman (1991) maintains that increased returns lead to a concentrated geographic pattern of innovation and development. With path dependence, both the starting point and accidental events can have significant effects on the ultimate outcome

Clusters affect competition in three distinct ways. They serve to increase the productivity of companies located in a specific geographic area; act as a catalyst for innovation; and foster the creation of new businesses and linkages (Ketels, 2003). The benefits of firms close geographic proximity to each other provides heightened access, stronger relationships, more information, and many other advantages that would prove difficult from a more remote location. The benefits or incentives of clustering are even more pronounced in today's knowledge based economy where innovation, cooperation, and motivation are at a premium (Malecki, 1997).

Economic clusters can be classified into a variety of groups. The most common methods of differentiation include the types of products produced, the location dynamics present, and the business environment in which the cluster operates (Ketels, 2003). Prominent clusters exist in the automotive, financial services, tourism, and high tech industries to name a few. The success of clusters and the geographic regions in which they operate can discourage competition from outside locations that do not possess the same competitive advantages (Saxenian, 1994). Some industries are strictly governed by location dynamics. Many industries are bound to certain locations out of a necessity to locate near their customer base, while others are forced to locate in close proximity to certain natural resources. The quality of the business environment can determine the effectiveness of a particular cluster. Stronger economic climates usually foster more productive clustering; however, clusters do not occur automatically and must be nurtured and maintained (Porter, 1985).

2. Technopoles, the New "E-conomy" and the Computer Manufacturing Industry

Allen J. Scott (1990) coined the term technopole to articulate the rapid growth of high technology districts in southern California. This term is now being used more frequently to analyze interfirm linkages and labor markets within high technology clusters throughout the world. Scott's work is of particular importance because of his focus on regions and their rising significance in the emerging new economy.

The growth of the New Economy is contingent upon the population developing and utilizing new innovative technologies. It is necessary for highly educated and trained individuals to continue research and development strategies that promote pioneering technology. These advances in technology must then trickle down through the workforce and all aspects of the economy, eventually becoming tools of everyday life in the home (Cohen et al, 2000).

The growing trend towards a more knowledge based economy is putting a heightened priority on education. Creative destruction is prominent in the world economy, older jobs and professions are being phased out as ones are created. The experience and skills necessary to compete in the new economy will require far more education and expertise than was required previously (Cohen et al, 2000).

The New Economy is most easily recognized in the high tech arena; however its influence is spreading throughout all industries (Atkinson and Gottlieb, 2001). It has come to symbolize the reorganization of firms to suit a more global economy, leading to a more dynamic and efficient way to transfer ideas and services all over the world. The same factors that are fueling the growth of the New Economy are also responsible for the evolution of economic geography in America’s metropolitan regions (Atkinson and Gottlieb, 2001).

The decentralization of metropolitan areas is occurring in response to the growing importance of technology and the internet. The percentage of employment for the largest metro areas, possessing over 1 million residents, declined from 55.1% to 54.3 % between 1988 and 1997; while the percentage of jobs in mid-size metropolitan areas, 250,000 to 1 million residents, rose by 4 percent. Finally, the share of jobs for small metro areas, those with 50,000 to 250,000 residents, increased by 7 percent (Atkinson and Gottlieb, 2001). The economic geography of both the United States and the World is evolving at a significant rate. The once held notion that cities and metropolitan areas are economically independent of one another is giving way to the importance of regions, linkages, and cooperation (Saxenian, 1994).

The landscape of metropolitan areas has changed considerably in the last 30 years. In the early 1990's 57 % of all office functions were located in the suburbs; this percentage increased from 25 % in 1970 (Atkinson and Gottlieb, 2001). There has been a dramatic decline in manufacturing employment in the United States, forcing workers to change careers and enter the high tech or business sector; which coincidentally are locating in the suburbs at ever increasing rates (Atkinson and Gottlieb, 2001).

A plethora of research has been compiled to illustrate the economic effect industrial clusters have on their surrounding regions. Furthermore, extensive literature can be found exhibiting methods whereby regions may become more attractive to an industry cluster. There is; however, surprisingly sparse information pertaining to variables that affect location decisions of the computer manufacturing industry. The remainder of this section of the literature review will analyze specific investigations of the high technology sector and conclude with a brief look at the computer manufacturing sector and some of the key organizations that comprise it.

Geographically Localized Knowledge Spillovers or Markets? by Armstrong et al, (1998) provides a specific investigation of the California biotechnology cluster. Armstrong et al, (1998) focus on the impact of research universities and the impact they have on knowledge spillovers in the biotech sector. Empirical evidence suggests that the traditional definition of geographical knowledge spillovers does not apply to the type of knowledge spillovers occurring in this study (Armstrong et al, 1998).

Armstrong et al, (1998) explain that biotech, like other high tech sectors, is characterized by natural excludability and human capital. This is largely because spillovers can only be instigated and performed by individuals who possess the knowledge to do so. The most common method of geographical spillovers operates under the premise that scientists are involved in basic research at the university. It is understood that the fruits of this research will quickly be transferred to the commercial sector.

The method of knowledge transfer in the biotechnology sector is much more defined. Scientists are usually contractually bound, or have a financial interest in the commercial development of their research. The majority of scientists are employees, or involved in a partnership with the enterprise promoting the final product (Armstrong et al, 1998).

The relationship between top scientists who work in academic institutions and high technology commercial development has valuable location consequences on firms. Scientists choose to work with or create firms in close proximity to their host universities, which most retain a relationship with (Armstrong et al, 1998). This phenomenon provides evidence of the economic linkages and spillovers that universities have on surrounding commercial firms throughout the biotech sector. Although this article focuses on biotechnology, empirical evidence suggests that linkages and knowledge spillover patterns will hold true for other high tech sectors as well (Armstrong et al, 1998).

Caron and Pouder (2006) attempt to distinguish between two generic types of clusters: technology based and industry-focused. Caron and Pouder (2006) argue that the two types of clusters can have dramatically varying effects on a region and create quite different sources of regional advantage. This is due in large part because resources are attained and nurtured through different approaches. Caron and Pouder (2006) illustrate the key differences in cluster types by examining two dramatically different cluster regions: Silicon Valley and Dalton, Georgia.

Industry focused clusters evolve over time, changing with life cycle of the specific industry. Specialization improves efficiency, which in turn provides tangible benefits for firms to locate at a specific location. Technology focused industries evolve, and new technologies spawn new products and entire new industries or spin offs (Caron and Pouder, 2006). Industry clusters tend to create a powerful proficiency in their particular industry; amassing pools of skilled labor, and strengthening network ties that reduce friction and promote a fluid integrated business cycle (Caron and Pouder, 2006). Technology clusters, by contrast, value technological discovery and entrepreneurial insight; commodities that are less tangible and more difficult to transfer. Technology clusters are attracted to regions possessing research universities and high quality of life that promotes innovation by fostering close ties between university researches and entrepreneurial business people (Caron and Pouder, 2006).

Beardsell and Henderson (1998) examine the spatial evolution of the computer manufacturing industry by 317 metropolitan areas in the United States. The health of computer industry proves to be somewhat disorderly, as both big winners and losers are common among metropolitan areas. Highly educated cities, such as San Jose, appear to have a much better chance of attracting and retaining the qualified labor pool required to sustain the computer manufacturing industry (Beardsell and Henderson, 1998).

Beardsell and Henderson (1998) empirically analyzed the 16 year period of computer development between 1977 and 1992. Local employment patterns remained relatively stable, even in times of economic decline (Beardsell and Henderson, 1998). The influence of local externalities was examined in an effort to quantify what effect they may have on employee patterns and to measure the productivity of externalities and the presence of regional knowledge gathering. Evidence suggests that industry externalities are present among non-affiliate plants; however, corporate plants tend to be self-reliant and not as susceptible to the affects of externalities (Beardsell and Henderson, 1998).

There have been enormous changes in the structure of the personal computer industry since the mid 1990s, mainly in response to technological change and competitive pressures throughout the industry. Vendors have implemented demand driven, built to order production techniques, outsourcing functions to suppliers in an attempt to curb total expenditures (Dedrick and Kraemer, 2005). Information Technology has greatly aided in linking members of the value network electronically, enabling the production cycle to function in a more fluid and efficient manner. According to transaction cost theory, firms organize themselves to attain more economical methods of production. Production costs include the resources needed to produce and deliver a product to the final consumer (Dedrick and Kraemer, 2005).

The personal computer is ultimately a modular product, where peripherals can be designed independently and integrated into the final product. A critical feature of the industry is the presence of de facto product architecture; this allows vendors to establish elaborate networks of suppliers to enhance efficiency. The current industry structure evolved as a result of three major factors that occurred in the late 1990s (Dedrick and Kraemer, 2005). The first was the rapid decline in personal computer prices which fell from roughly $ 2,500 to $ 500 during the decade of the 1990s. The second factor is attributed to an accelerated product cycle and level of innovation. Products were evolving at a rapid pace which led to increased depreciation. Finally, the third factor was the unparalleled success of the build to order strategy employed by Dell and Gateway (Dedrick and Kraemer, 2005).

The repercussions of the above mentioned factors became overwhelmingly apparent in years between 2000 and 2003. In 1995, of the top10 personal computer manufacturers, market shares ranged from 10% to 3%. They are as follows: Compaq-10%, IBM-8%, Apple-8%, Packard Bell-7%, NEC-4%, HP-4%, Dell-3%, Acer-3%, Fujitsu/ICL-3%, and Toshiba-3% (International Data Corporation). The same figures for 2004 show a remarkable change in market share: Dell-17.9%, HP-Compaq-15.8%, IBM-5.9%, Fugitsu/Siemens-4.0%, and Acer-3.6% (International Data Corporation). Dell's operational philosophy allowed it to increase market shares and become the number one personal computer manufacturer in world in 2001, and it has only increased its market share since (Dedridk and Kraemer, 2005).

Dell has adjusted its production and organizational philosophy to become the number one computer manufacturing firm in the world. The following investigation will examine key factors that influence the location of their plants. Dell has production capabilities throughout the world; however, at the time of this article only two plants existed in the United States: Texas and Tennessee. The following location factors were instrumental in Dell's final decision to construct a manufacturing facility (Dedrick and Kraemer, 2002).

Market access is critical in determining the location of manufacturing facility. All of Dell's plants are centrally located in the market in which they were intended to serve. Labor costs and quality is an important factor, as a firm would like to minimize costs while at the same time maximizing quality. Labor costs in Texas and Tennessee were relatively low due in large part to a minimal presence of labor unions. The presence of transportation corridors and telecommunication infrastructure is very important. This asset greatly enhanced Tennessee, as it is in close proximity to many major highways and a major Federal Express distribution center. Government incentives can help sway location decisions among relatively similar locations (Dedrick and Kraemer, 2002).

Finally, research indicates that Dell generally avoids locating near existing industry clusters (Dedrick and Kraemer, 2002). The majority of Dell's operations do not rely on specialized engineering capabilities, and Dell would like to locate where labor is less expensive. Dell does, however, insist that suppliers maintain inventory near production facilities to support their build to order production philosophy (Dedrick and Kraemer, 2002).

3. Computer and Electronic Product Manufacturing and Connections to Richard Florida's Creative Class

The computer manufacturing industry is thriving in today's knowledge based economy. It is, however, an industry that requires an educated, talented pool of labor. Richard Florida (2002) attempts to quantify talent, which he asserts is highly concentrated and vital to the economic health of the high technology industry. Florida (2002) defines talent as individuals with elevated levels of human capital, measured as the percentage of a population holding a bachelors degree or higher. Florida (2002) contends that talent is attracted by diversity and devised indexes to measure social amenities, including the coolness and diversity index. The median house-value and the per capita income of the region were tested against the above mentioned indexes (Florida, 2002).

This research has implications for the high technology industry, as Florida (2002) believes that empirical evidence illustrates that talent significantly influences the location decisions of high technology industries and regional incomes. These findings also hold pronounced value for regional development strategies. It is suggested that certain key regional social factors serve as powerful tools for recruiting talent. Regions may alter their public policy in an effort to become more open and diverse, thus evolving into a more talent friendly environment. Florida (2002) argues that a strong relationship exists between talent, diversity, and regional development; holding that diversity attracts talent, which is required to run the high technology industry.

Richard Florida (2004) developed a Creativity Index to quantify the attractiveness of particular geographic regions. This index is a composite of four indices: the Innovation Index, High Tech Index, Gay Index, and the Creative Class. The Innovation Index is based on the annual amount of patents recorded per capita. The High Tech Index is derived from two measurements calculated by the Milken Institute. The first measures a region's high tech industrial output as a percentage of the total high tech industrial output for the United States. The second calculates the percentage of a region's total economic output that comes from high tech industries. The Gay Index uses census data to measure if a region has an above or below average gay population. Florida (2004) believes an elevated gay population demonstrates a heightened sense of openness and tolerance, traits that are beneficial to high tech industries. The Creative Class uses occupational data to categorize types of employment. The Creative Class is made up of careers requiring independent thought and specific training or education. Members of the Creative Class range from art and design specialist to more analytical careers such as engineers or architects (Florida, 2005). Although Florida's work has helped to develop a better understanding of the creative process, it is unclear if such research accurately explains the geography of the computer and electronic product manufacturing industry cluster.

Overall the literature on the geography of the computer manufacturing industry is lacking in detail. Limited research has been done concerning key factors that influence location decisions for computer manufacturing industries, even though there has been substantial research on industrial clusters and the economic geography of specific technopoles. This thesis will try and pull from these arguments in an effort to determine in more detail what specific factors influence the locational patterns of the computer and electronic product manufacturing industry, (NAICS code 334).

CHAPTER III

RESEARCH DESIGN

1. Research Hypothesis and Definitions

The purpose of this thesis is to examine and better explain the spatial distribution of computer and electronic product manufacturing employment and establishments in the largest metropolitan statistical areas. It is hypothesized that the percent of employment in the computer and electronic product manufacturing sector is fundamentally shaped by several key socio-economic variables that act as surrogate measures of both skill levels and productive knowledge infrastructures. It will be argued that the geography of computer and electronic product manufacturing is strongly linked to specific socio-economic variables including educational attainment level, per capita income, median housing price, median age, percent foreign born, and percentage population growth rate from 1990 to 2005.

Part of this hypothesis is grounded in an attempt to empirically test Richard Florida's (2005) Creative Index which is a composite of four indices: the Innovation Index, High Tech Index, Gay Index, and the Creative Class. Richard Florida (2005) asserts that "the emergence of the creative economy in the United States has spurred innovation and productivity even as it reinforces and exacerbates economic and social inequality" (p. 281). By analyzing the spatial distribution of the computer and electronic product manufacturing industry and examining critical socio-economic variables, I hope to provide a better understanding of the competitive advantage of computer and electronic manufacturers for specific MSAs and empirically test the Creative Index listed in Richard Florida's (2005) *The Flight of the Creative Class.*

A. The Dependent Variable: Computer and Electronic Product Manufacturing

The dependent variable includes the percent of the labor force in computer and electronic product manufacturing establishments by MSA. The federal government uses the North American Industry Classification System to determine industrial designation, where all industrial establishments are defined according to their production process. The manufacturing sector is categorized and subdivided into specific industries, including a subsector dedicated to computers and electronics, (NAICS 334). The NAICS serves as the method of industry classification for data compiled by the Bureau of Labor Statistics (NAICS, 2002). The 2002 NAICS manual defines the NAICS 334 subsector as "Industries in the Computer and Electronic Product Manufacturing subsector group that manufacture computers, computer peripherals, communications equipment, and similar electronic products, and establishments that manufacture components for such products" (NAICS, 2002).

B. The Independent Variables

The majority of the independent variables are taken from the 2005 American Community Survey provided by the United States Census Bureau. The ACS supplied information concerning various socio-economic indicators including level of education, percent foreign born, median value of owner occupied housing, and per capita income. Educational attainment was quantified by the percentage of individuals 25 or older with a bachelor's degree or higher. Cultural diversity was calculated by subtracting the native born population from the total population, thus providing the percent foreign born. Population estimates for 2005 were also available from the ACS so that the population growth rate could be measured from 1990-2000 to 2005.

Data reflecting the research of Richard Florida was acquired from his book, *The Flight of the Creative Class* (Florida, 2005). Florida developed a Creativity Index, a composite of four indices: the Innovation Index, High Tech Index, Gay Index, and the Creative Class (Florida, 2004). This thesis will analyze Florida's composite Creativity Index to determine if it is related to the geography of NAICS 334.

C. The Unit of Analysis: Metropolitan Statistical Area (MSA)

The study area, or geographic scope of this research, is the Metropolitan Statistical Area. An MSA is a geographic unit defined by the Office of Management and Budget that possesses a minimum of one urbanized area of 50,000 or more inhabitants and adjacent communities that have a high degree of economic and social integration with the core area through commuting patterns. There are currently 361 Metropolitan Statistical Areas in the United States. Metropolitan Statistical Areas are defined by entire counties or other equivalent entities. The largest city in each MSA is identified as the 'principal city'. Principal cities consist of both incorporated places and census designated places to illustrate the more significant places in each MSA. The title of each MSA consists of the names of up to three principal cities and the state in which it is located. According to the Office of Management and Budget No. 04-03 published in

December of 2003, about 83% of the population of the United States is located within a MSA.

For this thesis, the top 100 MSAs, ranked according to total number of employees in the Computer and Electronic Product Manufacturing (334) NAICS subsector were chosen for further analysis. The 100 MSAs included in this study comprise over 78% of the total number of employees in NAICS 344. MSAs were chosen as the geographic scale of research because of their ability to capture regional labor markets. Although it is impossible to alleviate the modifiable areal unit problem completely, MSAs provide the best method for capturing regional networks and relationships. Trends at the MSA level may not be replicated at the county level.

D. Sources of Data

The dependent variable in this thesis includes the number of employees in the Computer and Electronic Product Manufacturing (NAICS 334) subsector that reported to the Bureau of Labor Statistics for 2005 by MSA. This data was collected in October of 2006 when it was categorized as preliminary. The BLS compiles data regarding the number of establishments, number of employees, and annual earnings for MSAs according to NAICS code annually. Data for 199 of a possible 361 MSAs was reported to the BLS in 2005. The majority of MSAs with nondisclosure issues were under 70,000 in population. A few critical locations known for computer manufacturing, such as Houston, Texas, also had nondisclosure issues. Although the data set is partially incomplete, the BLS Census of Employment and Wages remains the most comprehensive source of labor statistics at the MSA level.

It should also be noted the Richard Florida data was based on MSAs that met the 1999 standards set forth by the Office of Management and Budget. Some of these MSAs do not exactly match the boundaries of the 2003 MSA definitions; however, the majority of the MSA boundaries correspond with the new standards for the top 100 MSAs investigated in this thesis. The analysis will be based on a series of non-parametric Spearman's Rank Correlation Coefficients, which will be used to determine if statistically significant relationships exist between the dependent and independent variables. This method of analysis was chosen due to the skew and kurtosis associated with much of the data set. Data, used in the maps in the following Chapter, is categorized into like values through natural breaks. Maps and Scatter Diagrams are used to depict the spatial distribution of data in this thesis.

CHAPTER IV

FINDINGS

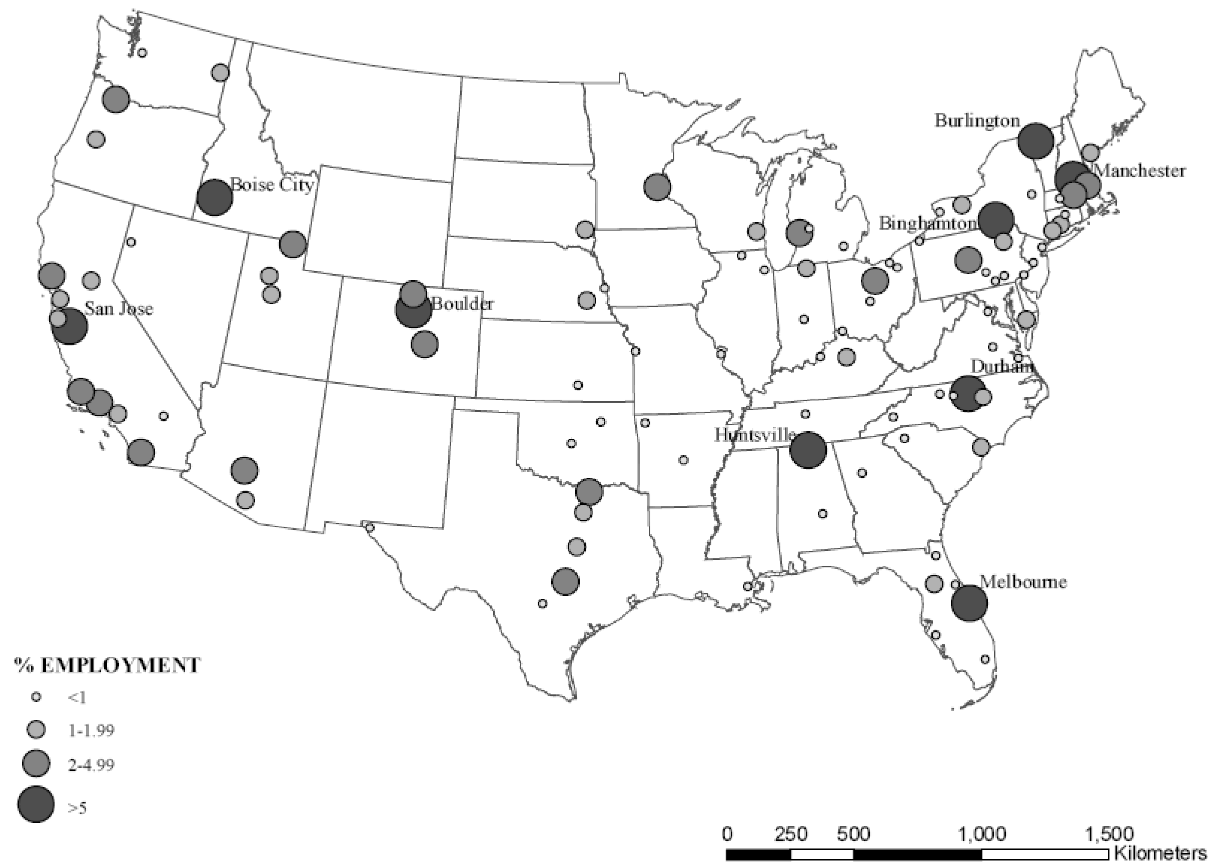
1. The Geography of Computer and Electronic Product Manufacturing

Figure 1 illustrates the spatial distribution by MSA of the percentage of workers employed in the computer and electronic product manufacturing industry (NAICS – 334) The 100 largest markets to report computer and electronic product manufacturing employment are depicted in figure 1 (which account for over 78% of the U.S. total in this industry). The metropolitan markets with a disproportionate share of the labor force in NAICS 334 included: San Jose-Sunnyvale-Santa Clara (13.2%), Binghamton (9.1%), Durham (6.8%), Manchester-Nashua (6.8%), Boulder (6.7%), Palm Bay-Melbourne-Titusville (6.4%), Burlington-South Burlington (5.8%), Boise City-Nampa (5.5%), and Huntsville (5.2%).

Substantial regional clusters of computer and electronic product manufacturing are clearly visible in the northeast U.S. and in central and southern California. The above average concentrations of NAICS 334 employees in these regions can be attributed to large technopoles, for example, Boston's famed Route 128 corridor and the San Francisco Bay Area's Silicon Chip Valley.

One of the most acclaimed areas in the world for high tech employment and computer and electronic product manufacturing is Silicon Chip Valley located in The San

Figure 1: Percent of Workforce employed in Computer and Electronic Product Manufacturing by MSA, 2005



Jose – Sunnyvale – Santa Clara MSA. The term "Silicon Valley" was introduced by electronics writer Don Hoeffle in the early 70s to describe the booming semiconductor and microchip manufacturing industry in the Santa Clara Valley, just south of San Francisco. The origins of the industry can be traced back to Frederick Terman, a professor that taught radio engineering at Stanford University. Terman was influential in recruiting venture capitalists and encouraging talented students to remain in the Palo Alto area. Varian Associates and Federal Telegraph, two of the most significant companies in the Valley, helped pave the way for the emerging semiconductor industry in the 1950s.

The creation of Stanford Industrial Park in the mid 1950s served as a conduit for the transfer of ideas and technology. The research park fostered relationships between emerging firms and the university. Fairchild Semiconductor, under the leadership of Robert Noyce, became the first firm to mass produce the Integrated Circuit. In the 1960s, Noyce and Gordon Moore of Fairchild Semiconductor left to form their own firm, Intel. Research at Intel focused on producing silicon chips with a maximum amount of circuits, or expanding the memory of the semiconductor chips as much as possible. This process reached a new level in 1971, when Intel developed its first microprocessor. By the 1970s a culture of innovation and competition was becoming increasingly prevalent; the infrastructure for "Silicon Valley" was now in place.

A powerful high technology cluster has continued to evolve in and around the Santa Clara Valley. New advances in computing such as nanotechnology continue to drive the industry forward and encourage innovation. The maturation of the high tech and computer product manufacturing industry is apparent from the restructuring of the industry from hardware to software. Although the manufacturing of hardware equipment remains a vital aspect of the Silicon Valley economy, software production continues to grow as less advanced manufacturing tasks are outsourced to other locations.

However, the climate is now conducive to promoting ‘off –shoot’ firms that help in the clustering of fresh ideas and new ways of thinking. There are a plethora of major high tech and computer and electronic manufacturing establishments in the Silicon Valley. Some of the most recognizable are Hewlett Packard, Cisco Systems, Sun Microsystems, Apple Computer, palmOne, Komag, and SanDisk. Research universities in the surrounding area include Stanford University, one of the nation’s premier research facilities, UC-Berkeley, UC-Santa Cruz, and UC-San Francisco. These institutions supply a talented labor pool which aids firms in research and labor recruitment. Other influential research centers include NASA-Ames, Lawrence Berkeley, Lawrence Livermore, and Sandia National Laboratory. The San Jose – Sunnyvale – Santa Clara MSA remains one of the most attractive locations for venture capitalists in the world. The positive characteristics and natural amenities of this area are vital in the cultivation and maintenance of a broad array of high tech firms.

Other concentrations of significant NAICS 334 employment can be found near Melbourne’s Space Coast in Florida and in Huntsville Alabama, both with significant links to NASA and related space technologies. The National Space Science and Technology Center is the catalyst for high tech success in Huntsville. The Research Triangle of North Carolina also boasts a healthy supply of high tech employment in large part because of its close proximity to three major research universities: Duke, UNC-

Chapel Hill, and NC State. Another distinct cluster of NAICS 344 employment is located in Colorado, which is heavily influenced by the research capabilities in Boulder, home to the University of Colorado. The United States Air Force Academy is located in Colorado Springs and utilizes some of the most advanced technology in the world.

Three relatively unusual locations for NAICS 334 include Boise, Burlington and Binghamton. The Boise Valley has blossomed into a high tech oasis and is now home to such innovative firms as Hewlett Packard, Micron Technology, and Cisco Systems. Boise possesses logistical accessibility to major markets, many natural amenities, and the cost of doing business is considerably cheaper than much of the west coast. Burlington, in the northeast U.S., is a technology hub where BTV (IBM – Burlington) produces advanced semiconductor technology.

Surprisingly, Binghamton, New York has the second highest concentration of computer and electronic product manufacturing employment in this study, with over 9% of the Binghamton workforce employed in NAICS 334 industries. Binghamton has been a manufacturing center since the Civil War, producing a wide array of products. Wealth from the booming manufacturing economy led to the building of elegant mansions and the city's nickname, the "Parlor City".

In 1889 Harlow Bundy founded the Bundy Time Recording Company in Binghamton. The company enjoyed tremendous success; and in 1905 moved its headquarters to nearby Endicott, where under the guidance of Thomas J. Watson became International Business Machine. IBM remains one of the most recognizable and influential firms in the world. Today IBM's Endicott facility is primarily involved in producing printers, storage devices, and providing IT services.

Binghamton also has a rich history in other forms of innovative high tech employment. In 1929 Ed Link invented the first flight simulator which was an invaluable tool during WWII. The production of simulators evolved to include driving, helicopter, naval, and NASA simulators. Success in the simulation industry is still enjoyed in Binghamton by companies such as Doron, NLX, and Binghamton Simulator.

Although the glory days of manufacturing in the northeast may be gone, the Binghamton MSA continues to attract new high tech industrial firms to the area. Lockheed Martin Systems Integration (Owego, NY) was awarded a $6.1 Billion contract in January of 2005 to build the latest US Navy Marine Corp helicopters for Presidential transportation. Other prosperous high tech firms in and around Binghamton include Country Valley Industries, American Board Company, Universal Instruments, and BAE Systems. Binghamton is in an attractive location and in close proximity to many metropolitan areas. It has a done a good job marketing its natural amenities and strong heritage.

2. Possible Explanations for the Spatial Distribution of Computer and Electronic Product Manufacturing by MSA

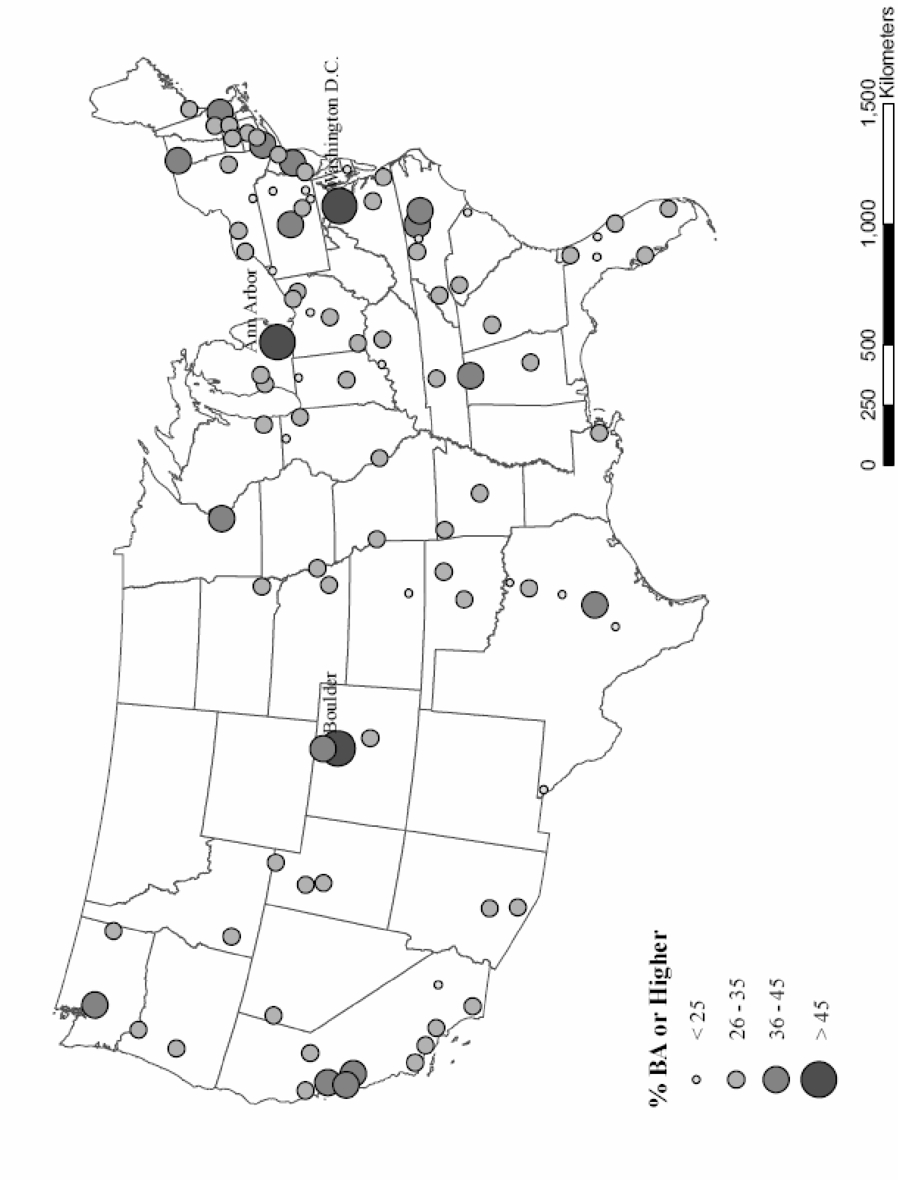
This section of the thesis outlines some of the potential explanations that might help further an understanding of the geography of computer and electronic product manufacturing employment and establishments by metropolitan area. Based on the hypothesis discussed in chapter three, this thesis argues that the percent of employment in the computer and electronic product manufacturing sector is fundamentally shaped by several key socio-economic variables. Specific variables believed to influence the spatial distribution of NAICS 334 employment include educational attainment level, per capita income, median housing price, median age, percent foreign born, and percentage population growth rate from 1990 to 2005. A second aspect of this hypothesis is grounded in an attempt to empirically test Richard Florida's (2005) Creative Index which is a composite of four indices: the Innovation Index, High Tech Index, Gay Index, and the Creative Class.

Due to the skew and kurtosis associated with much of the data set, a series of non-parametric Spearman's Rank Correlation Coefficients were calculated for the percent of the labor force in computer and electronic product manufacturing establishments by MSA and the various independent variables. Of the independent variables provided by the Census Bureau, the highest correlation scores included the percent of the population with a bachelor's degree or higher (0.32), median value of owner occupied homes (0.24), and the percent of the population not born inside the United States (0.20). The highest statistically significant correlation was Richard Florida's Creative Index Score (0.45). The remaining variables were not statistically significant at the .05 level.

A. Percent Bachelors Degree or Higher by MSA, 2005

Figure 2 illustrates the geographic distribution of advanced degrees throughout the United States for the 100 MSA's analyzed in this study. Advanced degrees are defined as the percentage of the population holding a bachelors degree or higher. There are three MSAs where over 45% of the population possesses advanced degrees including:

Figure 2: Percent Bachelors Degree or Higher by MSA, 2005



Boulder (57%), Ann Arbor (52%) and Washington-Arlington-Alexandria (45%). Boulder and Ann Arbor are home to the University of Colorado and the University of Michigan, both major state supported research institutions. The Washington D.C. MSA, although home to many world renowned universities including Georgetown University, George Washington University, and American University, is hardly considered a college town. However, the D.C. area is home to the United States federal government and several major employers including Fannie Mae, Marriot Hotel Services, and Blue Cross Blue Shield of the National Capital Area. Consequently the D.C. MSA attracts talented and well educated labor from around the globe.

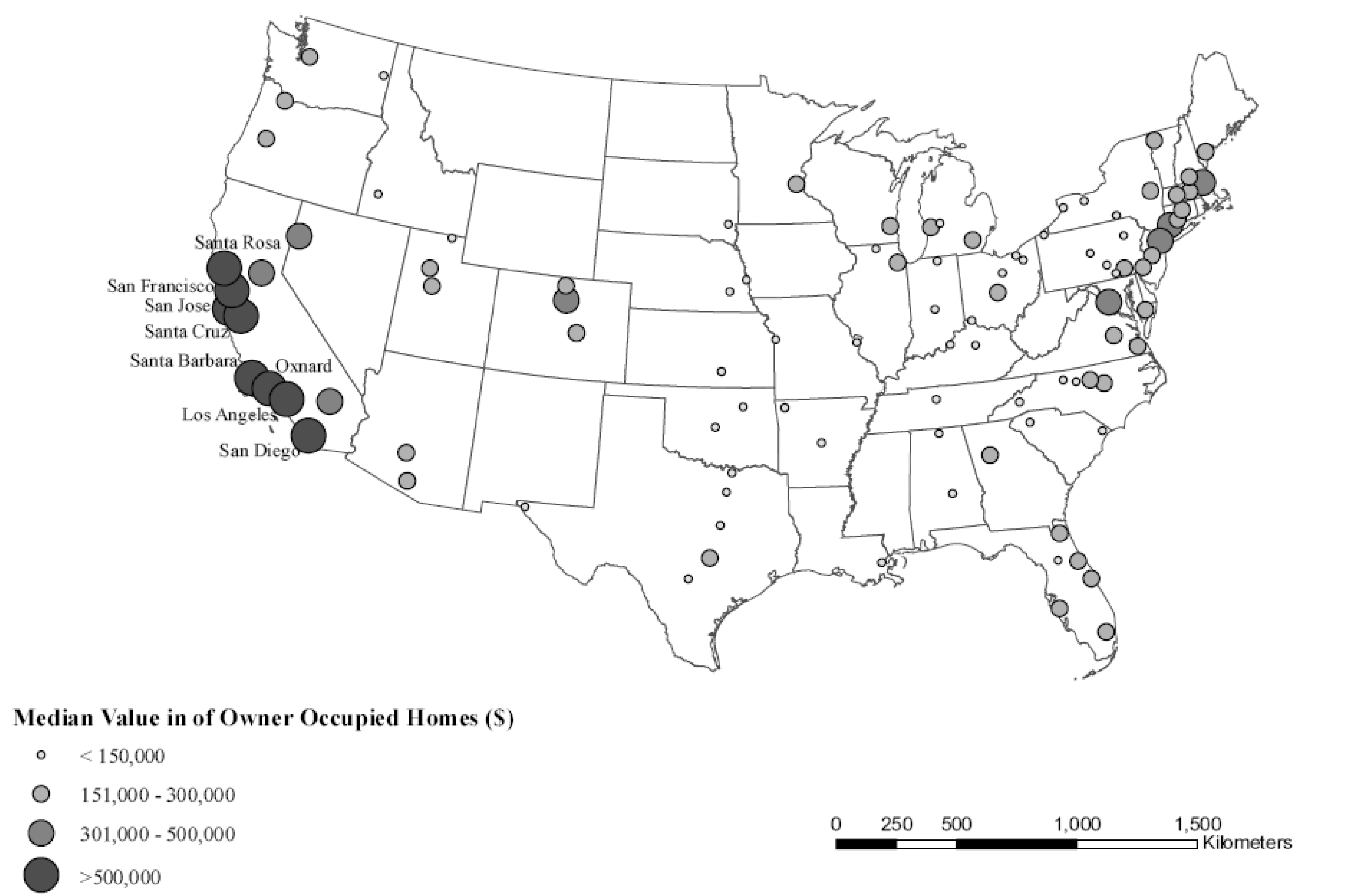
The relationship between a highly educated work force and the percentage of that workforce employed in computer and electronic product manufacturing is apparent when examining figures 1 and 2. There are dense supplies of well educated labor in the highly populated corridor stretching from Washington D.C. to Boston. For example, the Boston –Cambridge – Quincy MSA (40%) is home to a number of colleges and universities. Clusters of advanced degrees are also evident in the Raleigh-Durham area of North Carolina (Durham 43%, Raleigh 42%) and the Bay area of northern California (San Jose – Sunnyvale – Santa Clara 43%, San Francisco – Oakland – Fremont 43%). These geographical locations are served by some of the countries finest research universities and state of the art research parks.

Of the nine MSAs in this thesis, that had over 5% or more of the workforce in NAICS 334 employment, Binghamton, ironically exhibited the lowest percentage of college educated labor (24%). Although there are 14 colleges and universities located within 60 miles of Binghamton, none of them are particularly large. Binghamton and the surrounding communities of New York's Southern Tier are closely bound to their manufacturing roots. The main components of the local economy have either closed or greatly downsized their local operations. IBM, who employed over 15,000 workers, now provides just a few thousand jobs. Due to Binghamton's reputation for good schools and low cost of living, many of the recently unemployed have chosen to stay and accept jobs in the service sector. There has also been an upswing in small high technology companies such as Endicott International Technologies, who employ many former IBM employees.

B. Median Value of Owner Occupied Homes by MSA, 2005

Figure 3 depicts the spatial variation of the median value of owner occupied homes for the 100 MSAs investigated in this thesis. A cluster of high – end homes is clearly evident in central and southern California, where 8 MSAs experienced median values of owner occupied homes that are over $500,000. The northern California cluster includes Santa Cruz-Watsonville ($694,100), San Jose ($679,800), San Francisco-Oakland ($655,300), and Santa Rosa-Petaluma ($601,700). The southern cluster includes Santa Barbara ($646,300), Oxnard Thousand Oaks-Ventura ($602,700), San Diego ($552,000), and Los Angeles ($520,000). Home prices in California have risen at a rapid rate over the past decade, making home ownership elusive in many areas of the state. The real estate boom in California can largely be attributed to the rather limited amount of housing units and large number of potential buyers. Another cluster of high end owner occupied homes exists along the heavily populated northeast corridor. Bridgeport-

Figure 3: Median Value of Owner Occupied Homes by MSA, 2005



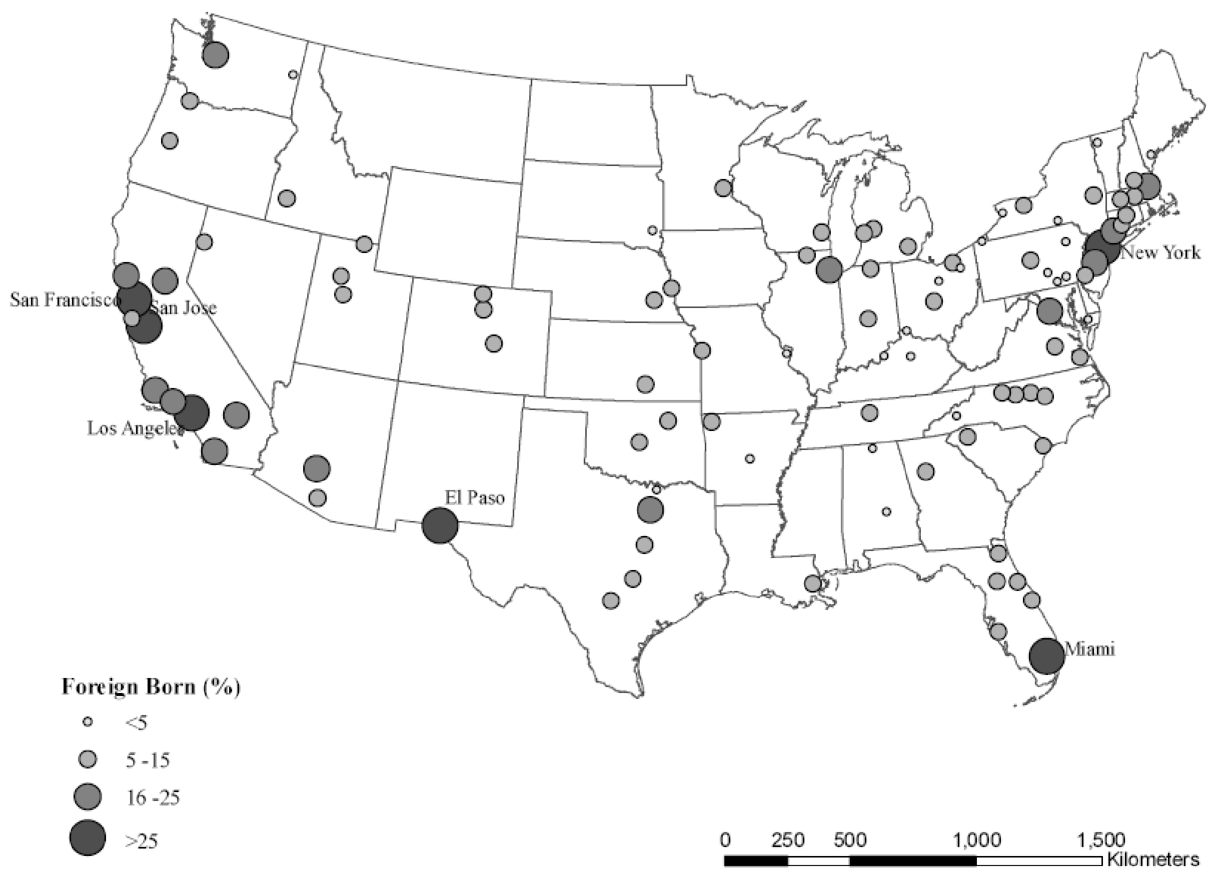
Stamford-Norwalk ($475,500), New York-Northern New Jersey-Long Island ($419,200), Washington-Arlington-Alexandria ($404,900), and Boston-Cambridge-Quincy ($394,800) are located within a single “Megalopolis”. The northeast possesses some of the most densely populated MSAs in the U.S., and in many cases there is a measurable shortage of developable land.

C. Percent Foreign Born by MSA, 2005

The percent of the population born outside the United States by MSA is spatially represented in figure 4. The four MSAs with the largest percentage of foreign born residents in this thesis are Miami-Fort Lauderdale-Miami Beach (36%), San Jose-Sunnyvale-Santa Clara (35%), Los Angeles (34%), and San Francisco-Oakland (29%). These MSAs are not only home to major international communities, but are located near the Mexican border or major ports of entry and are highly influenced by Latin American immigration. The New York-Northern New Jersey-Long Island MSA (27%) possesses the largest percentage of foreign born inhabitants not located within the southern tier of the United States.

Clusters of foreign born inhabitants are concentrated in California and the southwest stretching through Arizona, New Mexico and into Texas e.g. (El Paso, 27%). These MSAs, along with those in Florida, share strong ties with both Central and South America. Other large concentrations of foreign born residents can be found in most heavily populated cities. Large urban regions tend to be more diverse and welcoming to new ideas and culture.

Figure 4: Percent Foreign Born by MSA, 2005



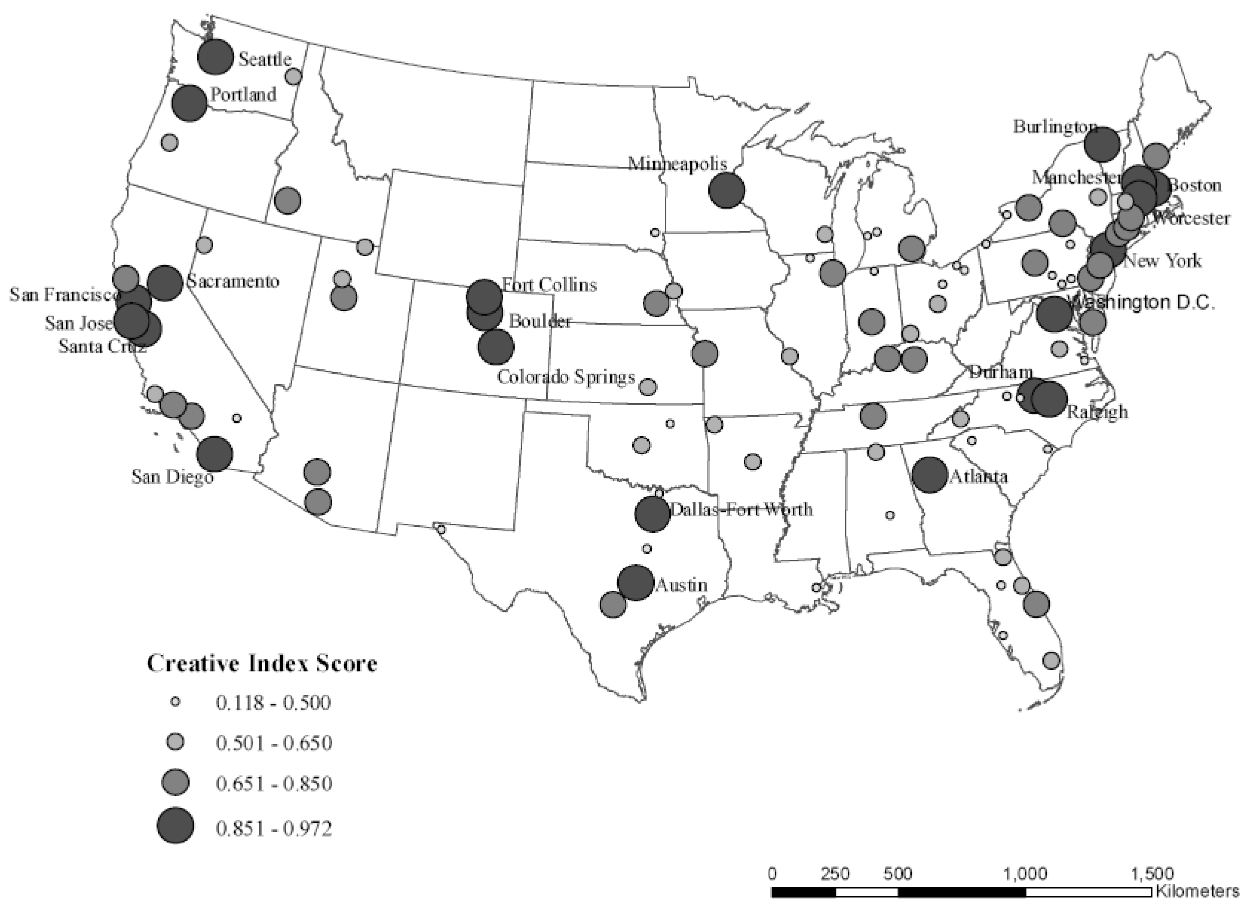
D. Creative Index Score

Figure 5 spatially represents Richard Florida's (2005) Creative Index which is a composite of four indices: the Innovation Index, High Tech Index, Gay Index, and the Creative Class. There are 22 cities with a Creative Index Score of 0.851 or higher clustered throughout the United States. The Index score is measured on a scale from 0 to 1, with 1 being the highest possible score and the highest level of creativity. The most evident cluster stretches from New England through to the Raleigh – Durham area of North Carolina to Atlanta and includes Boston-Cambridge-Quincy (0.945), Durham (0.915), Raleigh (0.915), Washington D.C. (0.907), Burlington-South Burlington, Vermont (0.905), Manchester-Nashua (0.904), Worcester (0.897), New York (0.872), and Atlanta (0.851).

Additional MSAs that scored high on the Creative Index were concentrated in California and in the Pacific Northwest. The highest scores in Northern California included San Francisco (0.962), San Jose (0.961), Sacramento (0.880), and Santa Cruz-Watsonville (0.863). The higher index scores in Southern California belonged to San Diego (0.858), while the Pacific Northwest cluster included Seattle-Tacoma (0.961), and Portland (0.908).

Clusters of high Creative Index Scores were also evident in several Texas MSAs and the Midwest. Above average scores in Texas and Minnesota included Austin-Round Rock (0.953), Dallas-Fort Worth (0.851), and Minneapolis-St. Paul (0.890). Boulder (0.972) possessed the highest Creative Index Score in this thesis and is a part of larger cluster including Fort Collins-Loveland (0.866) and Colorado Springs (0.853).

Figure 5: Creative Index Score by MSA, 2005



The relationship between the percentage of a MSAs workforce employed in computer and electronic product manufacturing and the Creative Index Score appears strong, as six MSAs rank among the top twelve in both categories. These MSAs included Boulder, San Jose, Austin, Durham, Burlington-South Burlington, and Manchester-Nashua. Florida's Creativity Index asserts that the current and potential employees in creative fields are particularly attracted to locations that possess elevated amounts of social capital. Figure 5 illustrates high Creative Index Scores in MSAs throughout the United States that are located in both densely populated metropolitan areas as well as smaller college towns. All of the elevated scores; however, are in locations where knowledge is particularly valued and diversity is prevalent.

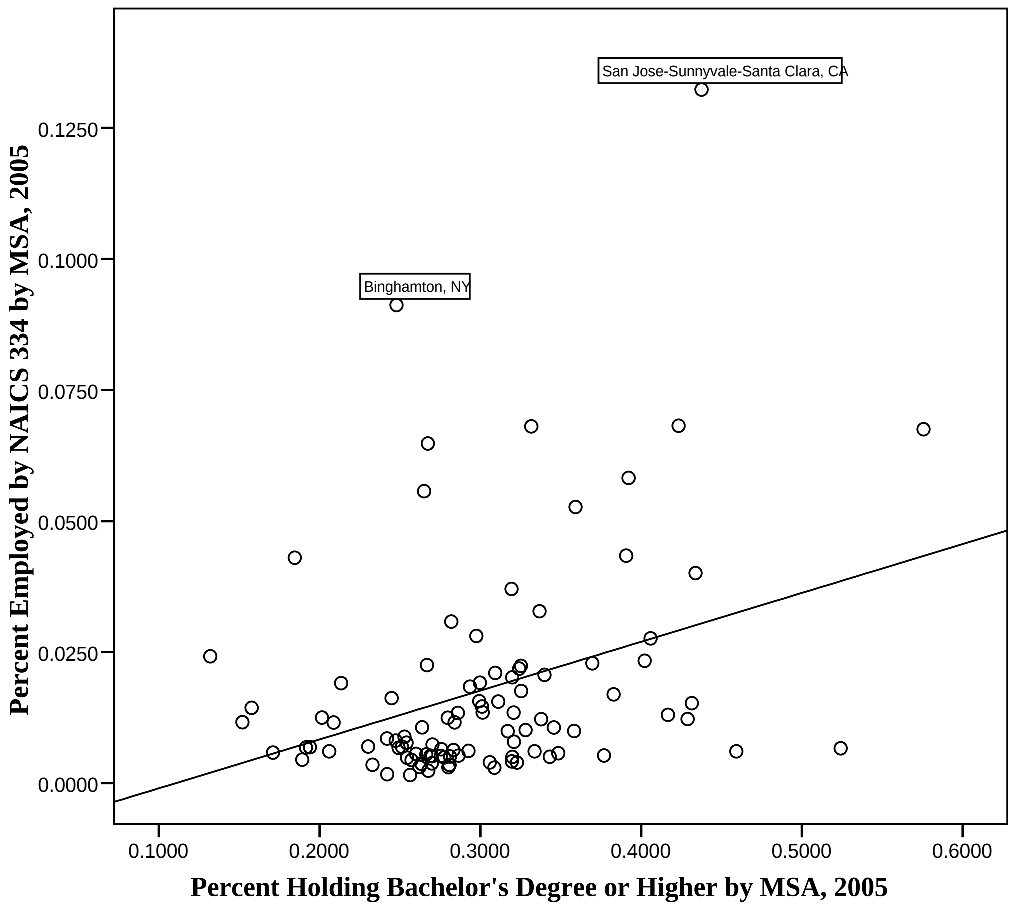
3. Results of Spearman's Correlation Coefficient and Scatter Plots

A. Percent NAICS 334 Employment and Percent Bachelors Degree or Higher by MSA, 2005

The scatter diagram depicting the relationship between the percentage of the population employed in computer and electronic product manufacturing and the percentage of the population with a bachelor's degree or higher by MSA (Figure 6) indicated that a positive linear relationship existed between the two variables (0.32 at the 1% level of significance). The general tendency of the scatter diagram indicates that as the percentage of advanced degrees in an MSA increased, so too did the percentage of the workforce employed in computer and electronic product manufacturing. This supports the general notion that employment in NAICS 334 requires the type of advanced training and skills associated with college degrees.

There were however, several anomalies that presented themselves including San Jose and Binghamton. San Jose, far and away, boasts the largest percentage of computer and electronic product manufacturing employees in the United States. At 13.2%

Figure 6: Scatter Diagram of % Employment in NAICS 334 and % BA or Higher by MSA, 2005



employment, it is over 4 percentage points higher than the next closest MSA (Binghamton, 9.1%). San Jose and the Silicon Chip Valley of California employ a highly educated workforce from around the globe. In the Binghamton MSA it appears that the percentage of the population holding a bachelors degree or higher is not sufficient to support the high volumes of workers employed by NAICS 334 industries. This is particularly noteworthy because Binghamton possesses the second largest percentage of NAICS 334 employment in the United States. Binghamton's unique economy has a rich history of both conventional manufacturing and high technology employment.

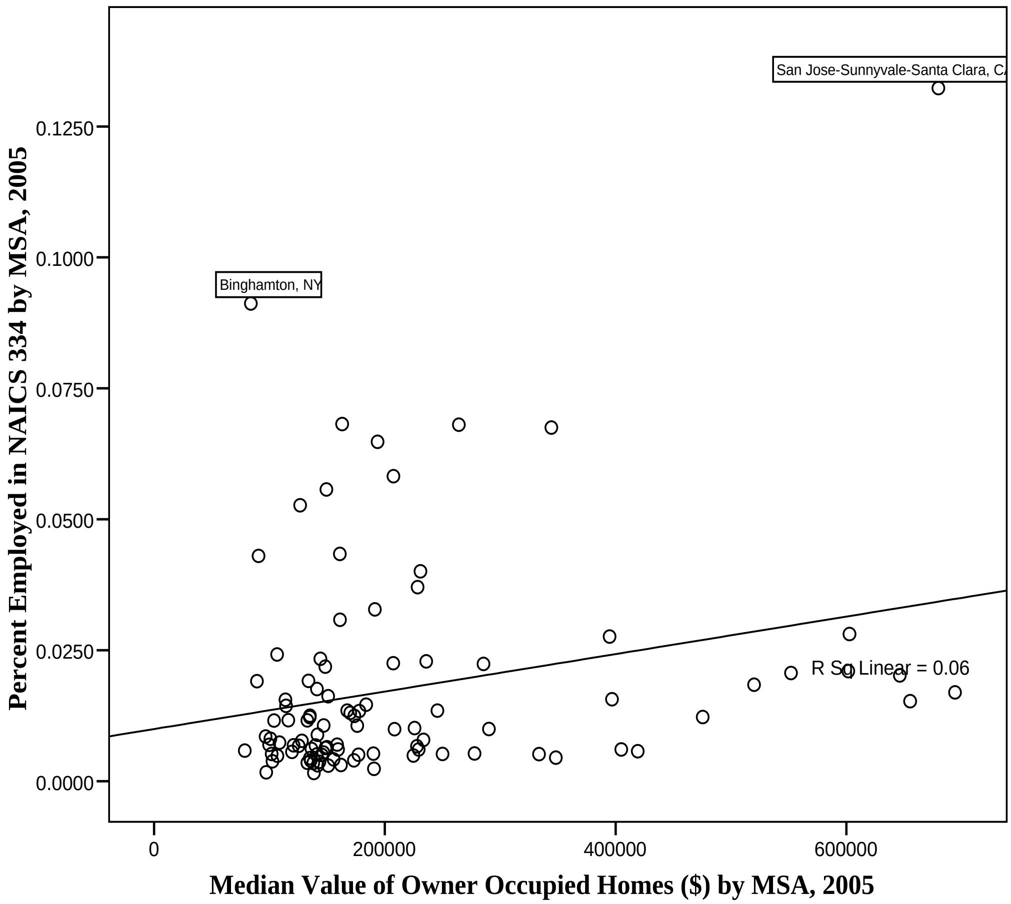
B. Percent NAICS 334 Employment and Median Value of Owner Occupied Homes by MSA, 2005

The scatter diagram of the percentage of residents employed in computer and electronic product manufacturing and owner occupied housing unit median value by MSA (Figure 7) indicted that a positive linear relationship existed between the variables (0.24 at the 5% level of significance). Figure 7 illustrates that an elevated percentage of NAICS 334 is statistically associated with higher median values of owner occupied housing units by MSA.

Several major anomalies or outliers are apparent, including once again San Jose and Binghamton. Real Estate in San Jose and California has risen at an impressive rate in the past decade driving home prices to record levels. A limited amount of housing coupled with a large pool of potential home buyers has led to higher median owner occupied housing values in San Jose and much of central and southern California.

However, other MSA with high percentages of NAICS 334 employment have maintained relatively affordable housing costs. Binghamton is one of the most affordable locations to buy a home in the United States; the median value for owner occupied homes is a mere $83,900 in the Binghamton MSA. The surplus in affordable housing is due in large part to heavy losses in the manufacturing sector and subsequent population decline.

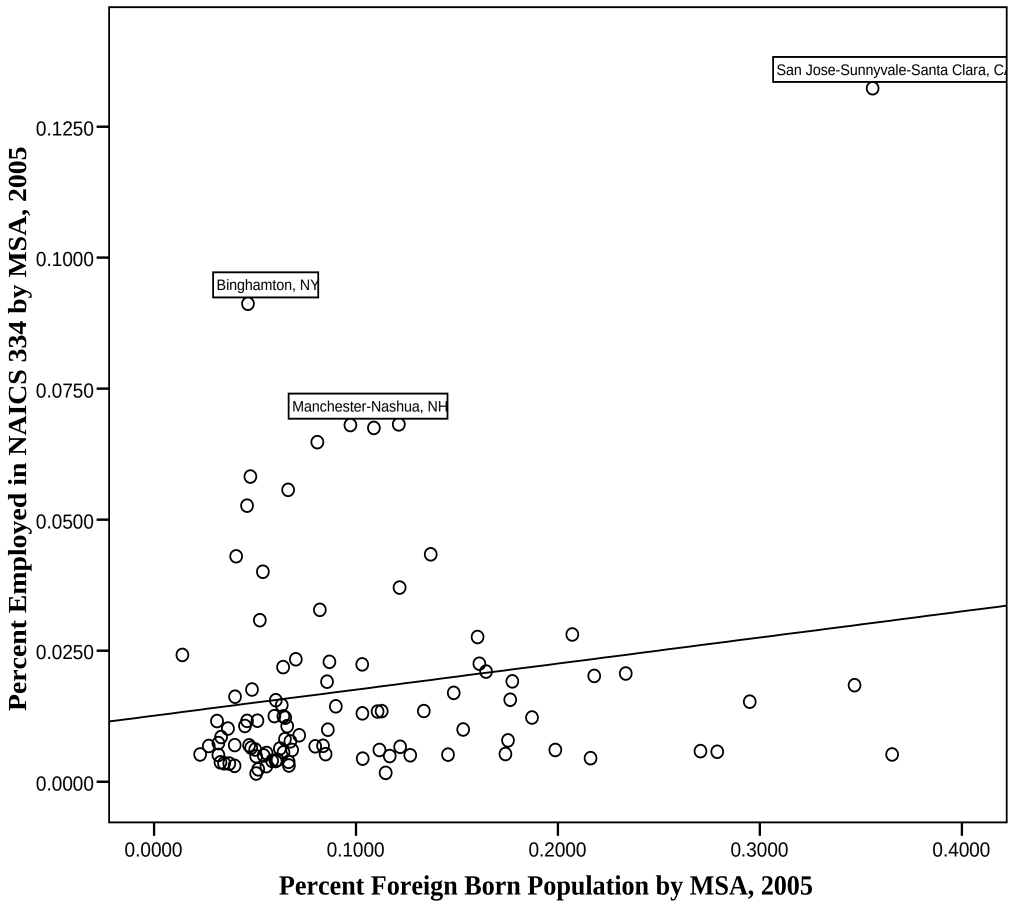
Figure 7: Scatter Diagram of % Employment in NAICS 334 and Median Value of Owner Occupied Homes ($) by MSA, 2005



C. Percent NAICS 334 Employment and Percent Foreign Born by MSA, 2005

The scatter diagram depicting the relationship between the percentage of the population employed in computer and electronic product manufacturing and the percent foreign born by MSA (Figure 8) indicated that a positive linear relationship existed between the variables. This was confirmed by correlation coefficient score of 0.20 at the 5% level of significance. Figure 8 illustrates a correlation that is relatively weak with many anomalies, the most significant of which include San Jose, Binghamton, and a cluster of other cities including Manchester – Nashua.

Figure 8: Scatter Diagram of % Employment in NAICS 334 and % Foreign Born Population by MSA, 2005



San Jose contains the largest percentage of computer and electronic product manufacturing employment in the United States by a wide margin. This MSA also ranks second in this study for percent of the population born outside the United States (35%). San Jose, like many areas in California, has strong ties to Mexico. The tremendous economic prosperity in the Bay Area of California coupled with its close proximity and relationship to Mexico serves to elevate the percentage of the population that is foreign born.

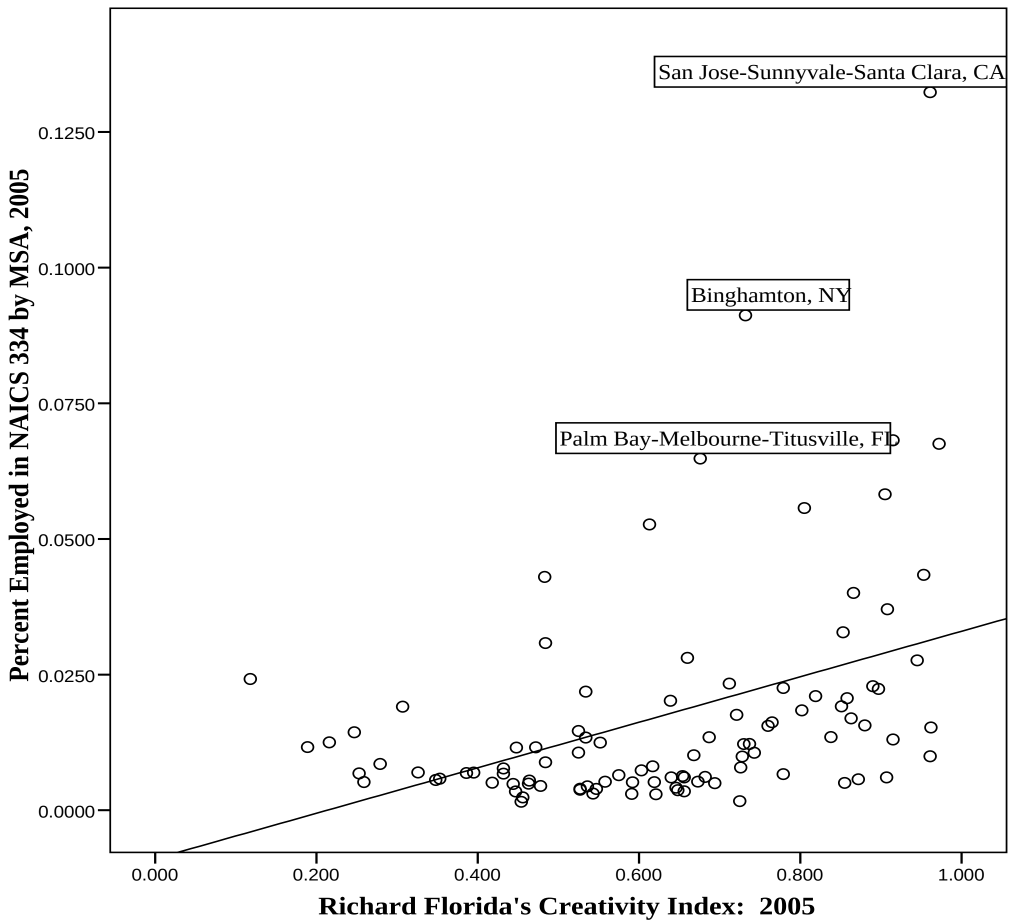
Binghamton (4%) and Manchester (9%) present striking anomalies and do not conform to the line of best fit. This is a result of their modest foreign born population. An examination of Figure 4 illustrates that large clusters of foreign born residents are mainly located near the Mexican border and major ports of entry.

D. Percent NAICS 334 Employment and Creative Index Score

The scatter diagram depicting the relationship between the percentages of the population employed in computer and electronic product manufacturing and the Creative Index Score compiled by Richard Florida (Figure 9) indicate that a positive linear relationship exists between the two variables (0.45 at the 1% level of significance). This is the highest coefficient score of all the variables discussed in this chapter. The general tendency of the scatter diagram indicates that as the percentage of advanced degrees in an MSA increased so too did the Creative Index Score. This supports the hypothesis that the NAICS 334 employment is closely bound to the Creative Index, a composite score meant to measure today's creative economy. Most of the MSAs are clustered around the line of best fit, suggesting that a strong relationship is present between the variables.

Overall, the scatter diagram revealed that the percentage of an MSA's workforce employed in computer and electronic product manufacturing increased proportionally with the Creative Index Score. There were however, several noticeable outliers including San Jose and Binghamton, to a lesser extent Melbourne. Although San Jose (0.96) ranks third among MSAs tested in this thesis for the Creative Index Score, it is located well above the line of best fit because of its dominance in NAICS 334 employment.

Figure 9: Scatter Diagram of % Employment in NAICS 334 and Richard Florida's Creativity Index



Binghamton and Melbourne are MSAs that both possess a NAICS 334 employment share of over 6% and are ranked 2nd and 6th respectively in this thesis on this measure. Creative Index Scores for Binghamton (0.73) and Melbourne (0.68), although high, do not appear high enough to support such high volumes of NAICS 334 employment. Unique circumstances in both locations help to explain their designations as technopoles. The Binghamton MSA is home to such high tech companies as IBM and Lockheed Martin, while Melbourne is located along Florida's Space Coast and employment is heavily influenced by NASA.

E. Overall Implications

The statistical and spatial analysis of the computer and electronic product manufacturing industry by MSA and the independent variables tested indicate the existence of several meaningful relationships. Some of the variables tested illustrate a larger influence on NAICS 334 employment; however, it is important to examine them all to better understand how they relate to each other and the dependent variable.

For instance, this thesis found that the percentage of a MSAs workforce employed in computer and electronic product manufacturing is greatly affected by educational attainment levels. The percentage of a population with a bachelor's degree or higher; however, can be influenced by a number of factors, including proximity to institutions of higher learning and various other knowledge intensive employment centers. Richard Florida's Creative Index generated the highest correlation scores relative to the geography of NAICS 334 employment, and seemed to better capture a MSAs attractiveness and skill level for computer and electronic product manufacturers.

The two largest tehnopoles or clusters of NAICS 334 employment found in this thesis were San Jose and Binghamton. San Jose, at the epicenter of Silicon Chip Valley, is relatively easy to explain. The Santa Clara Valley possesses enormous resources including access to excellent research universities and state of the art laboratories. It has a long history of producing semiconductors and microprocessors and a climate conducive to innovation and knowledge cultivation. Conversely, Binghamton is not as well known for having the attributes thought to be vital for success in NAICS 334 employment. It does; however, enjoy a rich history in both heavy manufacturing and in high tech employment. The birthplace of International Business Machine, Binghamton does an excellent job of marketing itself and attracting high technology employment.

It should be mentioned that several independent variables in this thesis were not statistically significant. The per capita income correlation coefficient of (0.15), median age (-0.12), and percentage population growth rate from 1990 to 2005 (0.12) were not statistically significant. This implies that the associational relationship between the percentage of a MSA employed in computer and electronic product manufacturing and these variables was weak or unsubstantiated.

The overall implications of this statistical analysis indicate that the geography of technopoles cannot be determined by simply examining one or two variables, but the combination of many variables may provide some insight into the spatial distribution of the computer and electronic product manufacturing industry. However, the unique characteristics of particular metropolitan areas may also lead to one variable being more influential than another.

CHAPTER V

CONCLUSION

The economy of the United States continues to evolve and change in response to globalization and the pressures of a world economy. Technology continues to develop and is serving as a catalyst for the global exchange of goods and services. As traditional manufacturing jobs are outsourced to various parts of the globe, the geography of the computer and electronic manufacturing industry may serve as a barometer for the health of the overall economy. The intent of this thesis was to investigate the spatial distribution of the computer and electronic product manufacturing sector by metropolitan statistical area in an attempt to better understand high tech clusters and the key critical variables that allow them to flourish.

It was found that large clusters of computer and electronic product manufacturing existed in the northeast U.S. and in central and southern California. A somewhat smaller cluster was found to exist in Colorado and was centered on Boulder. Also, it was observed, that across the country, there were some rather isolated regions with significant percentages of NAICS 334 employment which included Melbourne, Huntsville, and Boise (see Figure 1). In general, the logic for the geographical dispersion of computer and electronic product manufacturing employment can be attributed to various socio-economic factors such as educational attainment, home value, and the percent of persons born outside the United States.

A second aspect of my hypothesis was to empirically test Richard Florida's Creative Index, a composite of four indices: the Innovation Index, High Tech Index, Gay Index, and the Creative Class. This index emerged as the most accurate predictor of a MSAs ability to attract and maintain NAICS 334 employment. The Creative Index attempts to capture, often unquantifiable variables, such as social capital and natural amenities. These concepts may have a profound impact on the manner in which regions conduct public policy and market themselves to potential employers.

In no place is the validity of the Creative Index more apparent than in Binghamton, which has over 9% of its workforce employed in NAICS 334. Of the 100 MSAs tested in this thesis, Binghamton ranked 82^{nd} for percent Bachelor's Degree or higher (24%), 99^{th} for median home price ($83.900), and 82^{nd} for percent born outside the United States (0.05%). It is however, ranked 33^{rd} for the Creative Index Score (0.73). This Index was able to capture some of Binghamton's many advantages such as its affordable housing market, good job market, and its advantageous location to many adjacent metropolitan areas and natural amenities.

Throughout this thesis familiar anomalies were present and particularly apparent in the scatter diagrams (see Figures 6-9). This is because large clusters of NAICS 334 employment are confined to only a few MSAs. Only nine MSAs can boast employment shares of over 5% in computer and electronic product manufacturing employment. Of these, San Jose (13%) and Binghamton (9%) reported significantly higher market shares. An explanation for the emergence of these two technopoles lies in their ability to capitalize on each of their unique resources.

While this thesis has provided some insight into the geography of the computer and electronic product manufacturing industry by MSA, further research and emphasis should be placed on examining the various subsectors that comprise NAICS 334. This NAICS code is comprised of both research and development and manufacturing aspects of computer and electronic product manufacturing. Specific variables are certain to influence its subsectors in different ways. It would also be valuable to attain data for all MSAs in the United States. Nondisclosure issues limited the scope of this investigation. Furthermore, this thesis utilized correlation coefficient scores to establish associational relationships between the dependent and independent variables. Future research should employ a multiple regression model to analyze causal relationships that may exist among the dependent and independent variables.

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APENDIX A: DATA TABLE

MSA	Percent Employed in NAICS 334	Creative Index Score	Percent BA or Higher	Median Value of Homes ($)	Percent Foreign Born	Median Age	PCI ($)	Percent Population Change 1990-2005
San Jose-Sunnyvale-Santa Clara, CA	0.1323	0.961	0.4376	679800	0.3559	36.1	36543	0.1111
Binghamton, NY	0.0912	0.732	0.2478	83900	0.0465	40.0	21719	-0.1131
Durham, NC	0.0682	0.915	0.4233	163000	0.1212	34.8	27806	0.2075
Manchester-Nashua, NH	0.0681	0.904	0.3317	264100	0.0972	38.4	29303	0.1453
Boulder, CO	0.0675	0.972	0.5757	344300	0.1089	35.1	34156	0.2316
Palm Bay-Melbourne-Titusville, FL	0.0648	0.676	0.2673	193700	0.0809	43.1	24857	0.2345
Burlington-South Burlington, VT	0.0582	0.905	0.3922	207500	0.0477	37.8	28967	0.1030
Boise City-Nampa, ID	0.0557	0.805	0.2650	149400	0.0664	34.0	22489	0.3974
Huntsville, AL	0.0527	0.613	0.3592	126600	0.0461	38.1	27447	0.1829
Austin-Round Rock, TX	0.0434	0.953	0.3907	161000	0.1370	32.5	27695	0.3983
Sherman-Denison, TX	0.0430	0.483	0.1845	90600	0.0407	37.5	20797	0.1657
Fort Collins-Loveland, CO	0.0401	0.866	0.4338	230900	0.0539	33.9	26963	0.2971
Portland-Vancouver-Beaverton, OR-WA	0.0370	0.908	0.3194	228400	0.1216	35.7	26396	0.2615
Colorado Springs, CO	0.0328	0.853	0.3368	191400	0.0821	33.9	25389	0.2832
Holland-Grand Haven, MI	0.0308	0.484	0.2819	161200	0.0524	34.3	24727	0.2338
Oxnard-Thousand Oaks-Ventura, CA	0.0281	0.660	0.2975	602700	0.2071	35.4	29634	0.1453
Boston-Cambridge-Quincy, MA-NH	0.0276	0.945	0.4059	394800	0.1602	37.9	33388	0.0320
Mansfield, OH	0.0242	0.118	0.1320	106600	0.0140	39.4	21351	-0.0393
State College, PA	0.0233	0.712	0.4022	144200	0.0702	29.8	21800	0.0038
Minneapolis-St. Paul-Bloomington, MN-WI	0.0229	0.890	0.3697	235900	0.0869	35.8	30363	0.1747
Phoenix-Mesa-Scottsdale, AZ	0.0225	0.779	0.2668	207300	0.1611	33.5	24866	0.4117
Worcester, MA	0.0224	0.897	0.3252	285500	0.1031	37.7	27507	0.0655
Logan, UT-ID	0.0219	0.534	0.3242	148400	0.0639	25.7	17447	0.2558

Santa Rosa-Petaluma, CA	0.0210	0.819	0.3092	601700	0.1644	38.9	29509	0.1446
San Diego-Carlsbad-San Marcos, CA	0.0207	0.858	0.3399	552000	0.2336	34.4	28329	0.1155
Santa Barbara-Santa Maria-Goleta, CA	0.0202	0.639	0.3198	646300	0.2180	34.4	28405	0.0360
Dallas-Fort Worth-Arlington, TX	0.0192	0.851	0.2997	133900	0.1774	32.9	25768	0.3035
Waco, TX	0.0191	0.307	0.2134	89200	0.0857	32.4	19008	0.1186
Los Angeles-Long Beach-Santa Ana, CA	0.0184	0.802	0.2935	520000	0.3469	34.0	26193	0.1125
Lexington-Fayette, KY	0.0176	0.721	0.3254	141200	0.0485	35.6	25209	0.1520
Santa Cruz-Watsonville, CA	0.0169	0.863	0.3829	694100	0.1484	37.3	32752	0.0442
Salisbury, MD	0.0162	0.765	0.2448	150900	0.0401	36.9	23370	0.0903
Sacramento--Arden-Arcade--Roseville, CA	0.0156	0.880	0.2993	396900	0.1764	34.6	26606	0.2611
Rochester, NY	0.0156	0.760	0.3111	113900	0.0603	38.6	24518	-0.0061
San Francisco-Oakland-Fremont, CA	0.0153	0.962	0.4315	655300	0.2950	38.0	35918	0.0946
Milwaukee-Waukesha-West Allis, WI	0.0146	0.525	0.3010	183800	0.0632	37.1	26467	0.0327
Elkhart-Goshen, IN	0.0144	0.247	0.1577	114400	0.0900	33.6	21440	0.1888
Tucson, AZ	0.0135	0.838	0.3014	167400	0.1336	36.3	23045	0.2613
New Haven-Milford, CT	0.0135	0.687	0.3207	245600	0.1127	38.5	28857	0.0166
Salt Lake City, UT	0.0134	0.534	0.2860	177900	0.1107	30.2	23084	0.2452
Raleigh-Cary, NC	0.0130	0.915	0.4167	170000	0.1032	34.3	28335	0.4147
Myrtle Beach-Conway-North Myrtle Beach, SC	0.0125	0.216	0.2015	135100	0.0596	38.8	21856	0.3583
Eugene-Springfield, OR	0.0125	0.552	0.2797	173600	0.0640	38.0	21425	0.1368
Bridgeport-Stamford-Norwalk, CT	0.0122	0.737	0.4289	475500	0.1872	39.1	44591	0.0638
Lincoln, NE	0.0122	0.730	0.3378	135000	0.0650	33.7	23989	0.1455
Ocala, FL	0.0116	0.189	0.1520	116400	0.0512	43.5	20600	0.3408
Sioux Falls, SD	0.0116	0.472	0.2840	132800	0.0461	34.7	24462	0.2365
Scranton--Wilkes-Barre, PA	0.0116	0.448	0.2087	104000	0.0312	41.7	21181	-0.0888
Spokane, WA	0.0106	0.525	0.2638	147000	0.0450	36.2	22174	0.1511
Provo-Orem, UT	0.0106	0.743	0.3457	176100	0.0659	25.2	17836	0.3921
Portland-South Portland, ME	0.0101	0.668	0.3281	225800	0.0366	40.5	27020	0.1179
Seattle-Tacoma-Bellevue, WA	0.0100	0.961	0.3583	290200	0.1531	36.8	30554	0.1833

Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	0.0099	0.728	0.3170	208400	0.0861	37.9	28442	0.0370
Grand Rapids-Wyoming, MI	0.0088	0.484	0.2528	141600	0.0719	34.5	22880	0.1399
Erie, PA	0.0085	0.279	0.2419	96700	0.0332	38.5	20625	-0.0334
Wichita, KS	0.0081	0.617	0.2473	100900	0.0648	35.5	22823	0.1119
Chicago-Naperville-Joliet, IL-IN-WI	0.0079	0.726	0.3209	233500	0.1753	35.0	27829	0.1176
Winston-Salem, NC	0.0077	0.432	0.2541	128100	0.0675	37.1	23541	0.1731
Little Rock-North Little Rock, AR	0.0074	0.603	0.2702	108700	0.0319	35.9	23348	0.1424
Lancaster, PA	0.0070	0.326	0.2302	158700	0.0400	37.1	24254	0.1120
Buffalo-Niagara Falls, NY	0.0069	0.395	0.2512	99700	0.0471	39.8	23568	-0.0699
Rockford, IL	0.0069	0.386	0.1940	120900	0.0837	35.7	22210	0.1499
York-Hanover, PA	0.0068	0.253	0.1915	140000	0.0271	39.5	23521	0.1525
Greensboro-High Point, NC	0.0067	0.432	0.2491	125400	0.0798	37.1	22563	0.1793
Ann Arbor, MI	0.0067	0.779	0.5241	227900	0.1219	33.5	30579	0.1152
Asheville, NC	0.0065	0.575	0.2757	149900	0.0481	40.6	23511	0.1891
Nashville-Davidson--Murfreesboro, TN	0.0063	0.654	0.2833	148500	0.0623	36.2	25994	0.2428
Indianapolis, IN	0.0061	0.682	0.2926	136500	0.0501	35.0	25569	0.1955
Hartford-West Hartford-East Hartford, CT	0.0061	0.656	0.3337	229400	0.1116	39.8	31426	0.0146
Washington-Arlington-Alexandria, DC-VA-MD	0.0061	0.907	0.4592	404900	0.1987	36.0	37400	0.1947
Deltona-Daytona Beach-Ormond Beach, FL	0.0060	0.640	0.2060	159500	0.0684	42.7	22609	0.2199
El Paso, TX	0.0058	0.353	0.1710	78600	0.2706	30.9	14236	0.1648
New York-Northern New Jersey-Long Island, N	0.0057	0.872	0.3485	419200	0.2789	37.2	31244	0.0820
Greenville, SC	0.0056	0.348	0.2600	119600	0.0641	37.2	22148	0.1724
Cleveland-Elyria-Mentor, OH	0.0055	0.464	0.2664	146700	0.0557	39.0	24809	-0.0095
Trenton-Ewing, NJ	0.0053	0.673	0.3769	277700	0.1740	37.6	32336	0.0559
Springfield, MA	0.0053	0.558	0.2865	190100	0.0850	38.0	23606	-0.0291
Montgomery, AL	0.0052	0.259	0.2690	101900	0.0228	35.9	23233	0.1015
Miami-Fort Lauderdale-Miami Beach, FL	0.0052	0.619	0.2754	250000	0.3655	38.6	24912	0.2397
Reno-Sparks, NV	0.0052	0.592	0.2700	333700	0.1456	36.1	26807	0.3367
Akron, OH	0.0051	0.418	0.2811	141100	0.0319	38.3	24685	0.0393

Atlanta-Sandy Springs-Marietta, GA	0.0050	0.855	0.3432	177200	0.1269	34.1	27797	0.3644
Kansas City, MO-KS	0.0050	0.694	0.3199	145500	0.0543	36.1	26251	0.1430
Sarasota-Bradenton-Venice, FL	0.0049	0.463	0.2776	224800	0.1167	46.3	27963	0.2590
Tulsa, OK	0.0048	0.444	0.2544	106900	0.0506	36.5	22457	0.1231
Riverside-San Bernardino-Ontario, CA	0.0045	0.478	0.1892	348200	0.2162	31.1	21732	0.3237
Fayetteville-Springdale-Rogers, AR-MO	0.0044	0.536	0.2572	135100	0.1033	33.6	21181	0.3947
Columbus, OH	0.0042	0.646	0.3196	155600	0.0612	34.9	26033	0.1563
Richmond, VA	0.0040	0.527	0.3059	173200	0.0585	37.6	27547	0.1615
Omaha-Council Bluffs, NE-IA	0.0039	0.547	0.3228	135800	0.0602	34.7	25362	0.1381
Oklahoma City, OK	0.0038	0.527	0.2698	102600	0.0666	35.1	22998	0.1365
Cincinnati-Middletown, OH-KY-IN	0.0037	0.648	0.2634	143400	0.0329	36.4	25156	0.0895
Louisville, KY-IN	0.0035	0.656	0.2329	132800	0.0347	37.7	23827	0.1081
Harrisburg-Carlisle, PA	0.0035	0.447	0.2808	138000	0.0373	39.8	26085	0.0522
Jacksonville, FL	0.0031	0.543	0.2621	162000	0.0668	36.5	25420	0.2440
St. Louis, MO-IL	0.0030	0.591	0.2801	141800	0.0399	37.3	26161	0.0530
Albany-Schenectady-Troy, NY	0.0030	0.621	0.3087	151000	0.0556	39.0	27349	0.0081
Virginia Beach-Norfolk-Newport News, VA-NC	0.0024	0.456	0.2676	190600	0.0516	35.4	25090	0.0858
San Antonio, TX	0.0017	0.725	0.2420	97200	0.1147	33.8	21923	0.2366
New Orleans-Metairie-Kenner, LA	0.0016	0.454	0.2563	138500	0.0506	36.5	22540	0.0220